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Design Templates for Consumer use in Customising Additive Layer Manufactured Products

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ABSTRACT

This paper describes the creation of a design template for designing specific products for consumers. As an initial research design, it aims to develop an easy-to-operate design system, where consumers interact with design choices instead of operating conventional Computer Aided Design (CAD). This would help the end user, who would use the templates to “perform” aspects of the design and thereby endorse the manufacture of the products themselves. In terms of manufacturing products, several studies focus on involving consumers as much and as early as possible. Further, many studies have been concerned with Mass Customisation (MC) manufacturing combined with Product Family Architecture (PFA), which offers consumers a wide range of product choices. However, recent developments in the field of Additive Layer Manufacturing (ALM) have led to a renewed interest in how to manufacture customised products, and specifically, in ways that will allow consumers to create bespoke products more easily. These technologies can enhance the understanding of non-technology compliant consumers and bring the manufacturing process closer to the consumer. In time, ALM technologies might be more commonplace as a consumers’ home appliance rather than as commercial or industrial manufacturing equipment. Consequently, to make ALM more reliable and easier to operate by consumers, design aspects need to be developed to be as simplistic to operate in the same manner that ALM technologies have. This research suggests a user friendly design system by utilising design templates to simplify the CAD stages before manufacturing occurs.

KEYWORDS: Computer Aided Design, Design Template, Additive Layer Manufacturing, Mass Customisation, Product Family Architecture

1. INTRODUCTION

The design template is a simple program containing a database of Product Family Architecture (PFA), which allows consumers to configure the features or aspects of a products design and/or to individualise it and it should be easy-to-operate for specific products. In addition, the PFA must represent the Additive Layer Manufacturing (ALM) capability and the resultant output that can be realised by the specific ALM technology chosen for manufacturing the final desired product.

Research to date tends to focus on the consumers’ view rather than manufacturers’ view. Most studies in the manufacturing field use the conventional approach by bringing the consumers’ voice into the design and manufacturing processes [1]. This paper will use an inverted approach by bringing design and manufacturing to consumers, which allows consumers to be party to the design and manufacture of their products. For several decades, industries have shifted from production-driven and market-driven approaches to consumer-

driven approaches. It connects consumers' choices with the capabilities of the company, and extends the philosophy of concurrent engineering to sales, marketing and end users [2]. In the future, some manufacturers of commercial products might allow consumers to make their own products. For instance, in the past, consumers had to visit specialist photographic retailers to have their photographs printed, but now they can do the printing themselves, directly and easily, on printers at home. In the future, they would be able to print not only 2D products, but also 3D shapes [3].

The widespread use of the Personal Computer and its peripherals, as well as the internet and e-business has affected the behaviour of many consumers [4]. Additionally, it also allows easy and fast communication between the manufacturers and consumers so the manufacturer can grasp the consumer requirements, while the consumers express their particular needs [5]. In this way, consumers are accustomed to conveying their ideas, so the numbers of consumers who want to have their individual items will inevitably increase [6].

2. BACKGROUND AND AIM OF DESIGN TEMPLATE

2.1 Mass Customisation (MC) and Product Family Architecture (PFA)

MC, first conceived in 1987 [7], refers to the customisation and personalisation of products and services for individual customers at a mass production price. When the needs of custom products have increased in the market, many companies use MC as a strategic business operation. It has become an important trend in the manufacturing industry towards market globalisation, rapid technological innovation and intense competition [6].

One of the methods to achieve MC is through using PFA. This is defined as a group of related products that share common features and/or components and fulfil the need of niche markets. The product platform is a set of parts, subsystems, interfaces, and manufacturing processes that are shared among a set of products [8]. In this methodology, manufacture can offer its capability to match consumer needs through the configuration database. It contains a variety of product families and performs as a generic product platform for product differentiation in which individual consumer requirements can be satisfied through systematic decisions of developing product variants. Much research in these particular areas set the PFA as a representation of industries' capabilities [2].

However, in this study, all features must be able to be created by using ALM technology. Moreover, this report interfaces the PFA and is used as a software accompaniment to the ALM machine.

2.2 Computer Aided Design (CAD) and visualisation technologies

CAD has passed through a long era where it was perceived that only engineers were able to operate the software as the operation of CAD required lengthy specialist training, and the ability to understand sequences of commands to create or modify digital data. These days, this is not entirely the case.

The CAD industry has diversified its scope (Figure 1); it has achieved this by making CAD more detailed and specific for specialists, for example the invention of Piping CAD and Electrical CAD [9]. CAD has also become more user friendly, by implementing simplified and easy operational procedures (SpaceClaim [10] and Google Sketchup [11]). Further, for special interest/hobbies, CAD can enable customisation in the design level and thus, bringing consumers close to designing (e.g. of such special CAD software are BikeCAD [12] and Figureprint [13]).

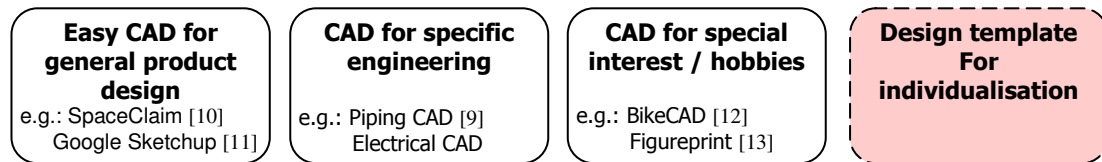


Figure 1: The purpose of CAD and Design Template

In addition, many researchers have made CAD easy by combining pen and tablet to facilitate freehand sketching to construct a 3D design [14], as well as combining with Haptics to shape a 3D virtual surface [15]. Thus, with such developmental progress, CAD has taken one step further to becoming a stylish designer tool.

However, these technologies approach the designers' needs, rather than consumers' needs. For the creation of design tools for consumers, this study will propose a simple program and no costly devices to help consumers design their ideas.

Virtual Reality (VR) technology, as a visualisation tool, immerses people into reviewing many aspects of a design, e.g. shape, structure, and function of the product, well before the product is manufactured. Moreover, it has left out the physical prototyping process. Simple VR has been used as the virtual product where the end user can assess the suitability of a design. Supported by the PFA and the internet, consumers can take part in the product design and link their demand to industries' offerings [16]. In the same context, the design template, presented by this research, offers ALM facilities as well as reviewing the final design.

2.3 Additive Layer Manufacturing

ALM is one of the most significant current manufacturing technologies that vastly expands the opportunities and has positive impact on the way we manufacture products. In addition, additive processes, which generate parts in a layer-upon-layer fashion, have more than 20 years of history. In its formative years, the purpose of these technologies was to make prototypes, but now it is no longer exclusively used for prototyping. In recent years, one has observed a move from Rapid Prototyping (RP), to Rapid Tooling (RT) and then to Rapid Manufacturing (RM).

New opportunities and applications in appropriate manufacturing tasks are opening up, even though the economic impact is still modest. The ALM machine is now becoming affordable to small businesses and potentially to the individual consumer [17, 18]. As a result, manufacturing has taken several steps closer to consumers (Figure 2). In addition, processes

such as 3D printing, show that this technology is easier to use, relatively inexpensive to operate and office friendly [19].

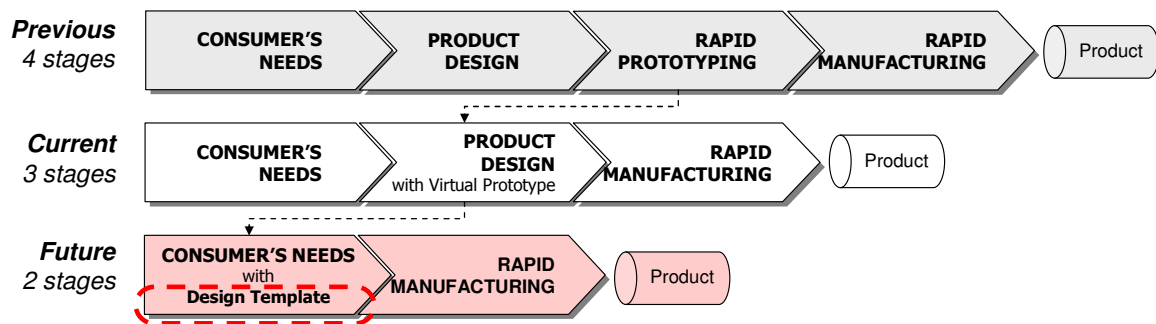


Figure 2: Reducing the production stages to realise consumers input to manufacturing

3. RESEARCH DESIGN

3.1 Research opportunity

With such developments, CAD has taken one step further to become a stylish designer tool, where previously only the design engineer used it (Figure 3). As they do in physical model, the virtual clay system allows designers to easily create, modify and evaluate shapes of products by interacting with a virtual model through a Haptic tool operated with their hands [15].

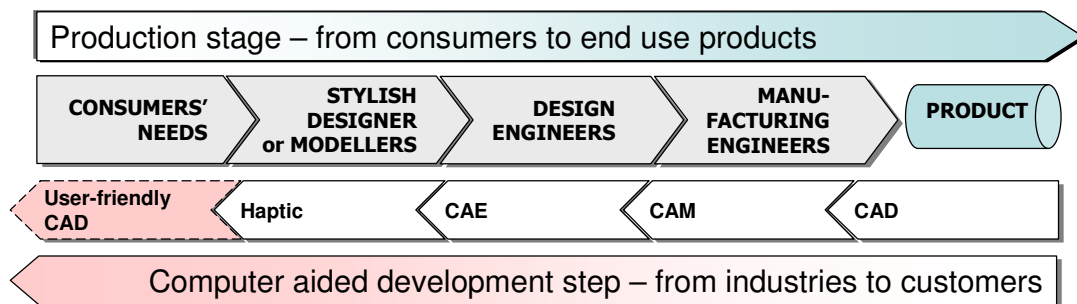


Figure 3: CAD/CAM/CAE/Haptic progression

So far, 5-finger Haptics are already on the market and are still used only to manipulate the assembly [20], rather than to modify the form of 3D digital model. With regards to the background of ALM advantages and to bring manufacturing closer to consumers, the research to date tends to focus on extending the CAD to consumers as users.

To overcome the problem, an easy-to operate design tool is needed so that the consumer is able to carry out any design personalisation or customisation according to their individual desires and taste.

3.2 Design template system architecture

Figure 4 displays the simple design template, which provides PFA. With this design template, users do not only choose the part but also can determine the features on the part. It is similar to some shoe manufacturers who serve consumers on their websites by allowing them to decide on the colour theme that they desire, place or locate logos and apply their own text [21].

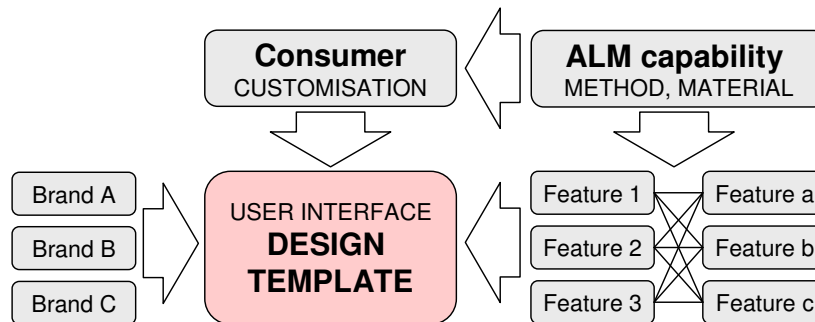


Figure 4: Simple design template

This research interfaces the database and features with simple html format and the 3D modelling database created by SolidWorks Publisher. So, consumers are able to decide and review the final design by rotating and panning it without the need for costly CAD software.

3.3 Design template for mobile phone cover

The research will take a case study of manufacturing the cover of a mobile phone (Figures 5 and 6) which can be manufactured using ALM technology and customised if and where appropriate. Three brands of each kind of device will be chosen as an example. For the device covers, consumers will be offered features as follows: Option 1 is sock type where the consumer can lay a lithophane (image), logo or name in front of the screen; Option 2 is fit type, i.e. it can have a flip screen cover or not, and as in Option 1, it is possible to place graphics on the screen cover or print text as well.

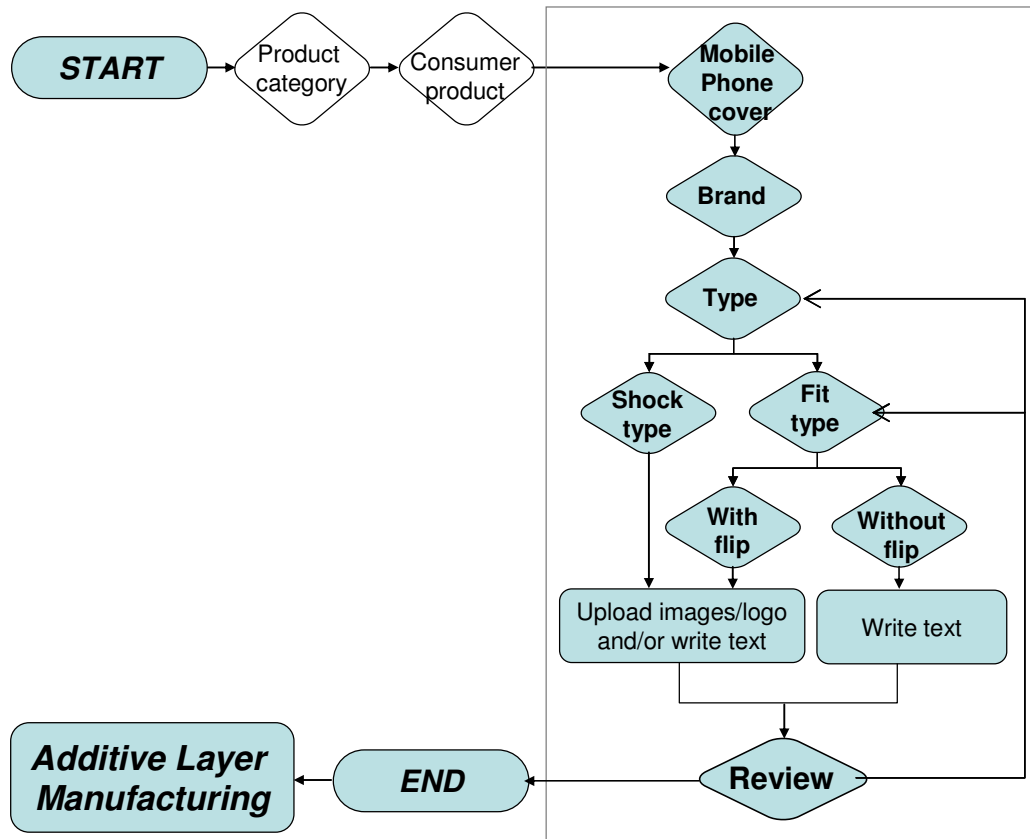


Figure 5: Flow process of Design Template of mobile phone cover

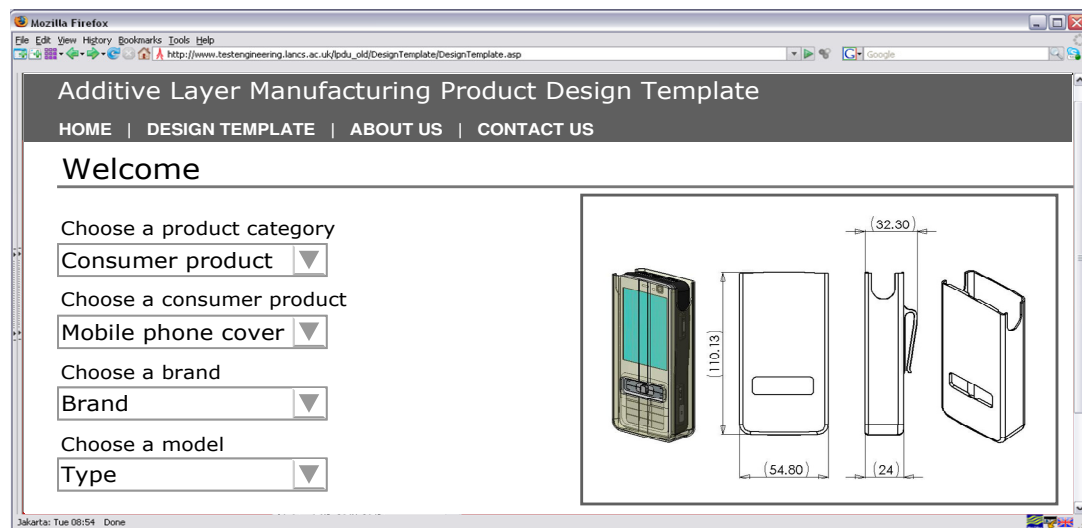


Figure 6: Design template of mobile phone cover

It follows that the 3D model will appear and the consumer will evaluate whether the product is ready to be manufactured or go back to the previous step.

4. CONCLUSION AND FUTURE WORK

In regards to the view of consumers, the ALM machine has to be tried as a home appliance or in a small office so that a user-friendly design template system can be developed. PFA, as a part of the design template, represents the capability of ALM, whereas it is usually used as a representation of the industries capability.

The design template could be employed by consumers as the software that goes along with the ALM hardware. Furthermore, it could also be used by Small Medium Enterprises (SMEs) who produce specific products and repeat their designs for a wide range of variants.

This research suggests that the Design Template has the capability for customisation e.g. by placing Lithopane images and/or text on the screen cover; and printing 3D models on ALM machines. However, the interface between Design Template, customisation features (uploading photo/image/logo, texting) and pre-manufacturing process (creating STL file) still needs to be developed in the future.

Similarly, patterns with manufacturing that have stepped closer to consumers and in line with the MC trends, design aspects should also be developed to become closer to the non-technology compliant or inexperienced users and SMEs. As a result, the use of design templates for specific products would grow widely. With regards to Open Source Software and the internet social networking trends [22, 23], it would be appropriate to create a Portal for ALM Design Templates to accommodate the design templates of other specific products.

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